CHAPTER IV

SOME CHARACTERISTICS OF THA CHIN ESTUARY

4.1 Hydrology

The Tha Chin river starts from Amphoae Wat Singh, Chainat Province at which the Chao Phraya river and Klong Mahkkamtao, originated from the mountainchain in Amphoae Ban Rai, Audthaithani Province, are met. The Tha Chin river is 295 kilometers long and before it reaches the Upper Gulf, it passes through 13 Amphoae as follows :

a) Chainat Province

Amphoae Hanka

b) Suphanburi Province

Amphoae Bang Nang Bouch

Amphoae Sam Chuk

Amphoae Sri Prajun

Amphoae Maung

Amphoae Bang Pla Ma

Amphoae Song Pee Nong

c) Nakorn Patom Province

Amphoae Bang Laen

Amphoae Nakorn Chaisri

Amphoae Sam Pran

d) Samut Sakorn Province

Amphoae Kratum Ban

Amphoae Ban Paew

Amphoae Maung Samut Sakorn

The Tha Chin river has four Irrigation Gate for water level control and flow control in irrigation canal for argricultural purpose which can be listed as follows : (Figure 4.1.1)

1) Pol Thep Irrigation Gate at Amphoae Wat Singh, Chainat Province which control the Chao Phraya's and Klong Makhamtao's discharge into Tha Chin river.

2) Tha Bhoat Irrigation Gate, Amphoae Bang Nang Bouch, Suphanburi Province

3) Samchuk Irrigation Gate, Amphoae Samchuk, Suphanburi Province

4) Po Phraya Irrigation Gate, Amphoae Muang, Suphanburi Province which is the last irrigation gate of Tha Chin river. This gate will prevent salt intrusion along Tha Chin river and flood in Amphoae Song Pee Nong and also used for irrigation purpose.

Mean monthly discharge of Tha Chin river, measured at Po Phraya Irrigation Gate, has reached maximum value about 120 - 130 m^3/s during September to November and gradually decreases to minimum about 20-40 m^3/s during January to March and increases again(This mean value are calculated from data during 1973 - 76).

The tide also has an important effect on water characteristics.

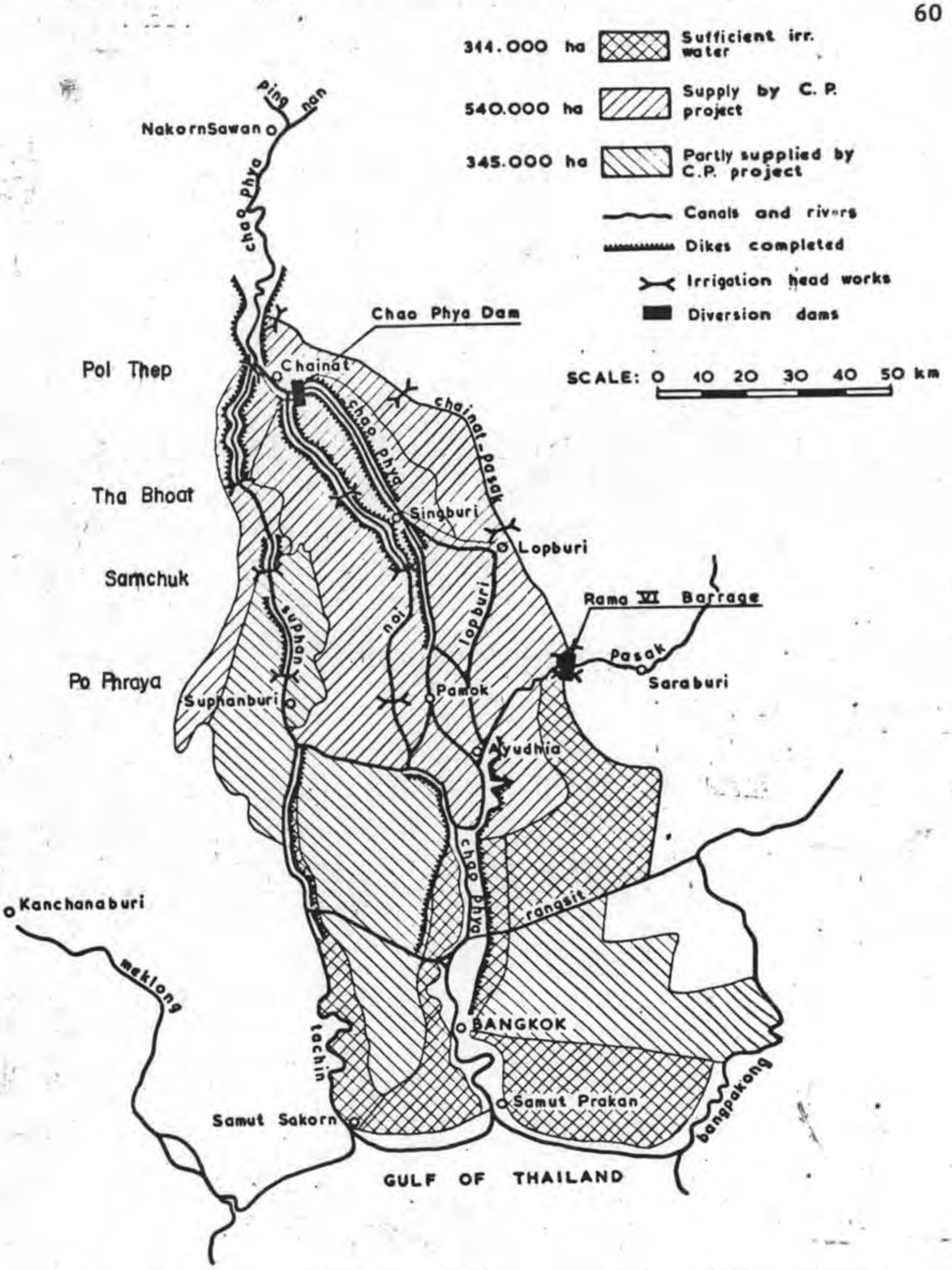

Figure 4.1.1 Illustrating the overall channel course of Tha Chin river. (after AIT, 1978).

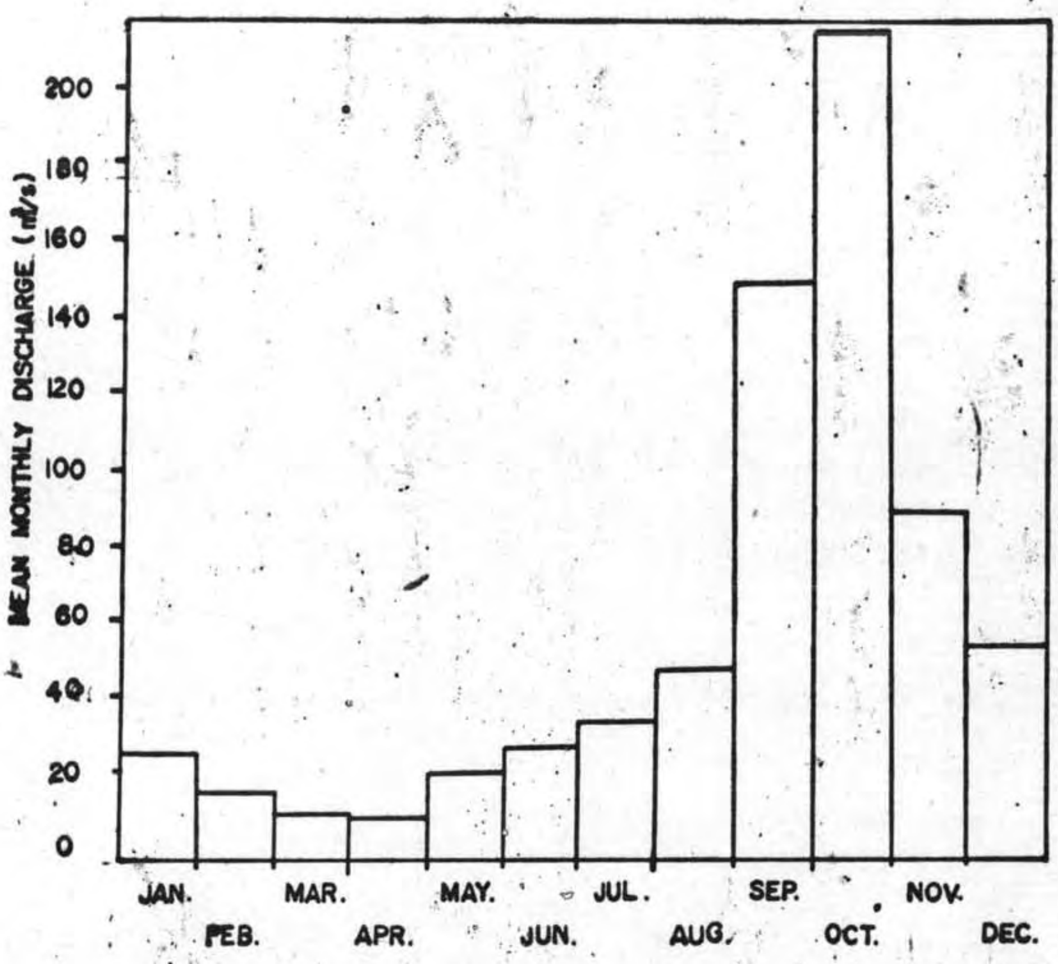

Figure 4.1.2 Mean monthly discharge of the Tha Chin river at Po Phraya, during 1969 - 1977 (after AIT, 1979).

Tides in the Upper Gulf of Thailand at Tha Chin river mouth is of mixed type : during the spring tides the tidal range varies between 2.5 to 3.5 meters and during the neap tides it varies between 1.5 to 2.0 meters. From November to January the tidal range varies greatly, from about 3.5 meters at spring tides to about 1.5 meters at neap tides. From February to April the tidal range does not vary very much, from 2.5 meters at spring tides to 1.8 meters at neap tides (after AIT, 1979).

In the Upper Gulf there are shallow areas in the western and northern parts (Figure 3.2.2). In these areas drift currents move with the wind while compensating currents flow through the deeper eastern parts. Winds from the south and west cause a clockwise circulation with a west to east littoral drift along the northern coast. Northerly and easterly winds generate current in opposite directions. (NEDECO, 1965).

4.2 Estuarine Oceanographic Parameters

4.2.1 Salinity Pattern

Generally, the salinity of the estuarine water, as determined at the center of channel course of every traverses throughout 3 field investigation programmes within the distance of 10.6 kms. upstream from the river mouth reveals a distinctive decrease in values. The salinity of 9-27‰ at the mouth of the rivers have been recorded as compared with the value of 3-26.8‰ at the distance of 10.6 kms. upstream. However, a certain degree of salinity fluctuation has been noted both seasonally and geographically. The result of 3 salinily patterns carried out in 3 different field surveys are summarized and presented in Figures 4.2.1a, 4.2.1 b, 4.2.1 c.

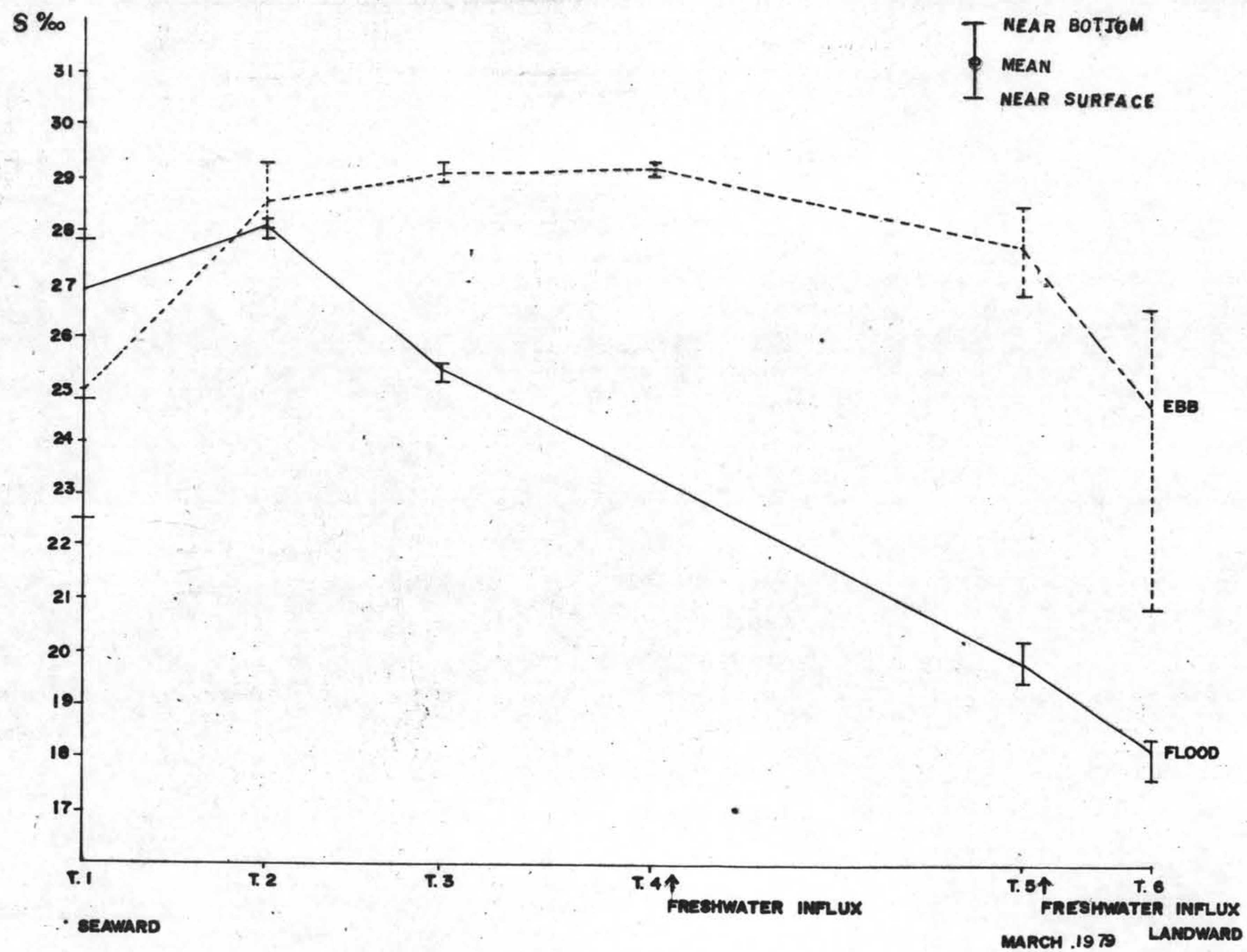

FIGURE 4.2.10 ILLUSTRATING THE SALINITY PATTERN ALONG THE MID-CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING LOW-FLOW.

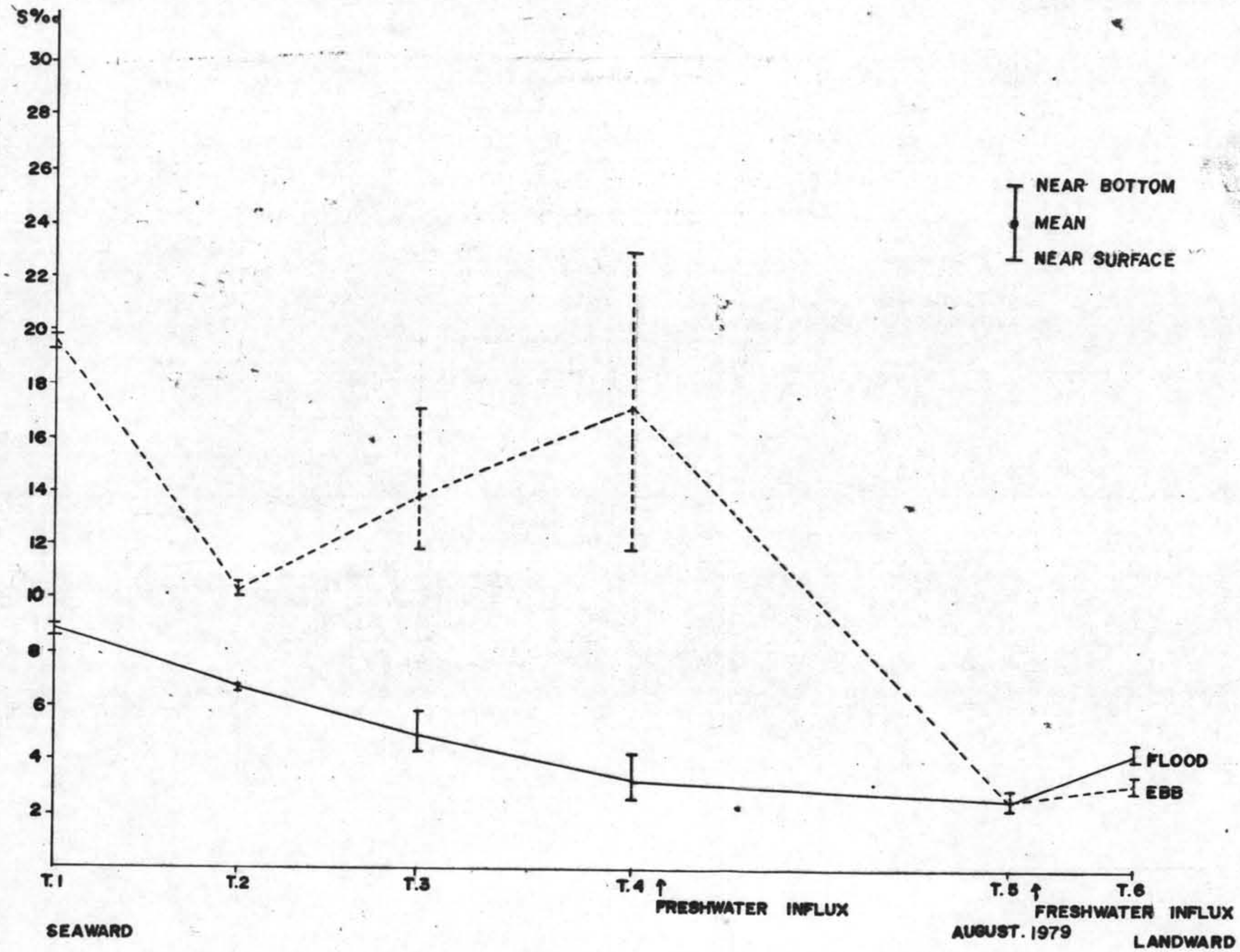

FIGURE 4.2.1 b ILLUSTRATING THE SALINITY PATTERN ALONG THE MID-CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING HIGH-FLOW

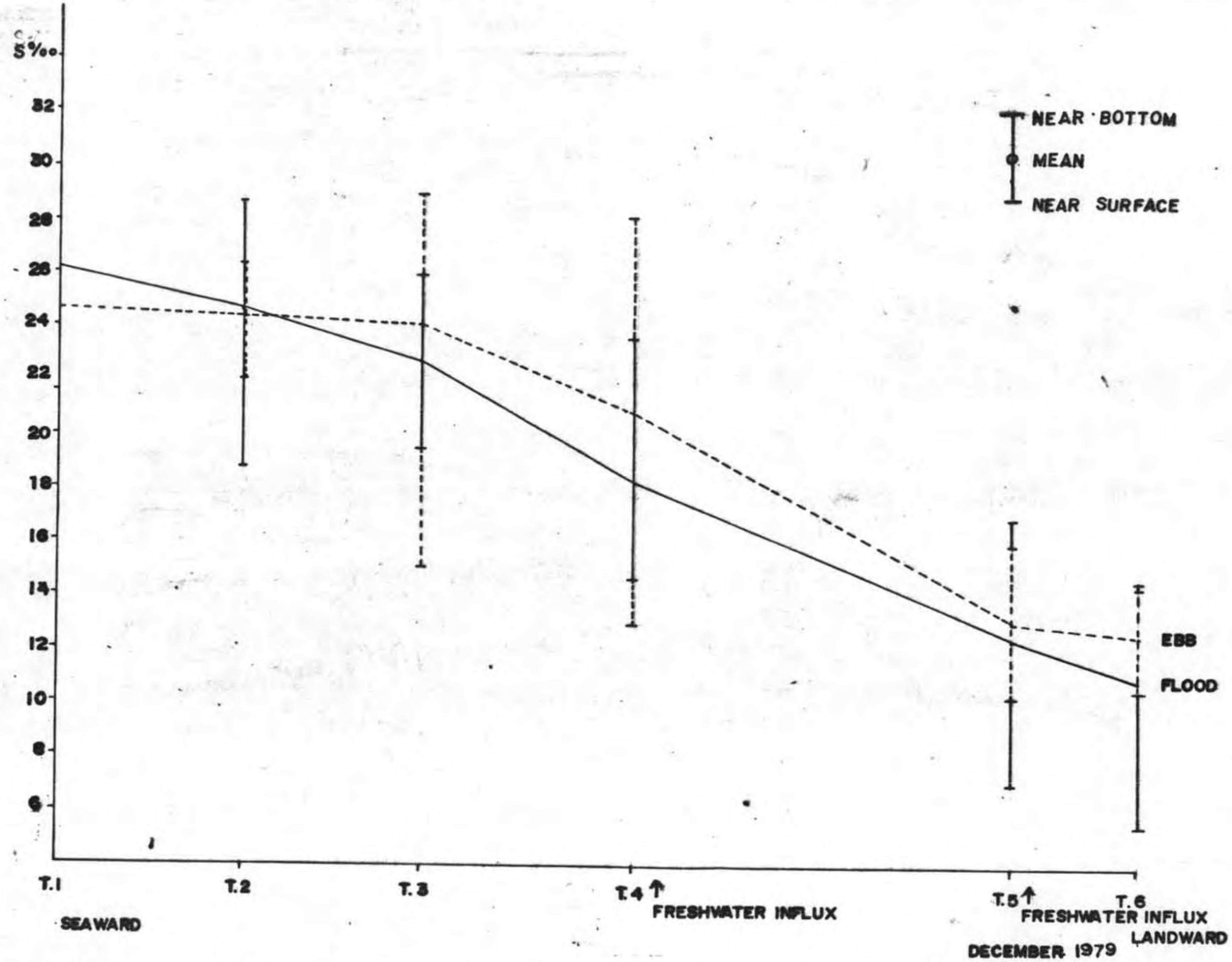

FIGURE 4.21 C ILLUSTRATING THE SALINITY PATTERN ALONG THE MID-CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING INTERMEDIATE-FLOW.

In the diagrams previously mentioned, the salinity values during flood and ebb of the mid channel course measured at the near-surface, near-bottom and mean values are presented against the distance of the channel course. Data obtained from the 3 field surveys, namely, low-flow period, intermediate-flow period and high-flow period are separately presented. Besides, the influx of freshwater from Klong Sunak Hon (between T5 and T6) and Klong Mahachai (between T4 and T5) are included in the illustrations.

During the low-flow condition of Tha Chin river in March (Figure 4.2.1 a), it is apparent that the salinity at the river mouth is relatively high (27-28‰) and the value progressively decreases upstream in the flood stage to 18‰ at T6 (10.6 kms. upstream from the river mouth). On the contrary, during the ebb stage the salinity fluctuation is not remarkably high along the channel course with the values vary in the range of 25-29‰. The freshwater influx from both Klong Sunak Hon and Klong Mahachai plays little influence in the salinity of Tha Chin river.

During the high-flow condition in August (Figure 4.2.1 b), the salinity slightly decreases from the river mouth from 9‰ to the 4.5‰ at T6 in the flood stage. However during the ebb stage the salinity along the channel course shows drastic fluctuation from 19.8‰ at the river mouth to 3.2‰ at T6. It is also interesting to note that the freshwater influx plays an important role in the decrease in salinity of Tha Chin river especially Klong Mahachai during the ebb stage.

In addition, the salinity pattern of Tha Chin river during the intermediate-flow (Figure 4.2.1 c) shows a rather uniform upstream decrease picture with only slight variation during the ebb and flood stages. The salinity values decrease from 24-25‰ at the river mouth to 12-13‰ at T6 with a slight fluctuation at the two positions of freshwater influx.

4.2.2 Current in River Channel

Data obtained from the three field investigation surveys regarding the current speed in the mid channel course at all channel traverses covering the channel distance 10.6 kms. during both flood and ebb stages are summarized and presented in Figure 4.2.2 a, 4.2.2 b, 4.2.2 c. The vectors of current speed employed in these presentations are normalized current speed (vector perpendicular to the channel travere) at near surface, mid-depth and nearbottom.

Theoritically, the normal current distribution with depth is the hyperbola form which its apex at 0.4 of total depth from the surface and the velocities decrease gradually both to the surface and to the bottom. The normal current distribution from previous mentioned figures show deviation from theoritical form which may be resulted from the salt intrusion into the river channel. The maximum deviation occurs at low-flow and intermediate -flow stages. Deformation of current speed pattern is more pronounced near the river mouth and reaches maximum at the river mouth. At high-flow stage the deviation occurs seaward from T3.

4.2.3 Dissolved Oxygen

The data on dissolved oxygen in terms of per cent saturation from 6 mid-channel stations measured at the near-surface, near-bottom, and

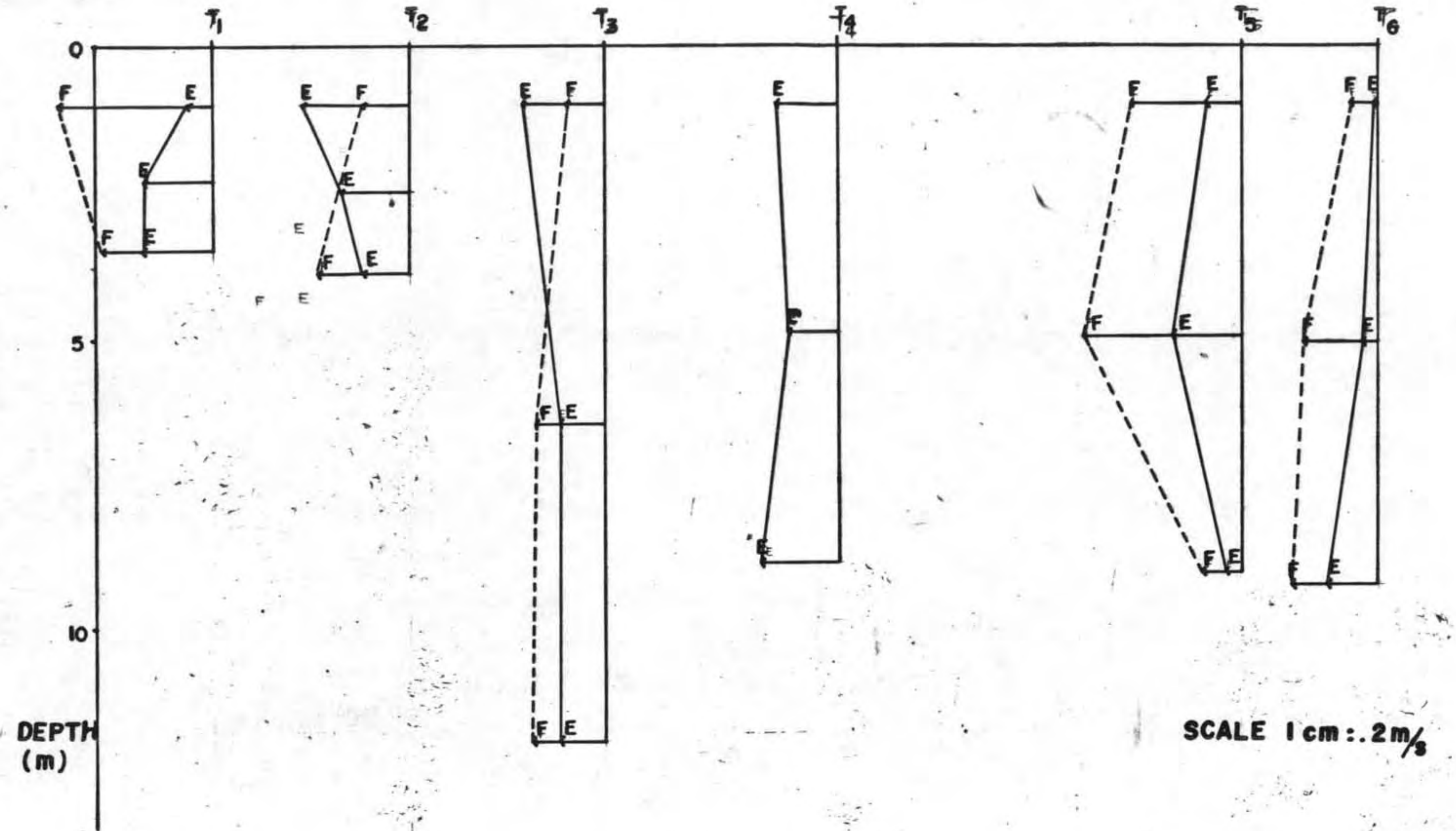

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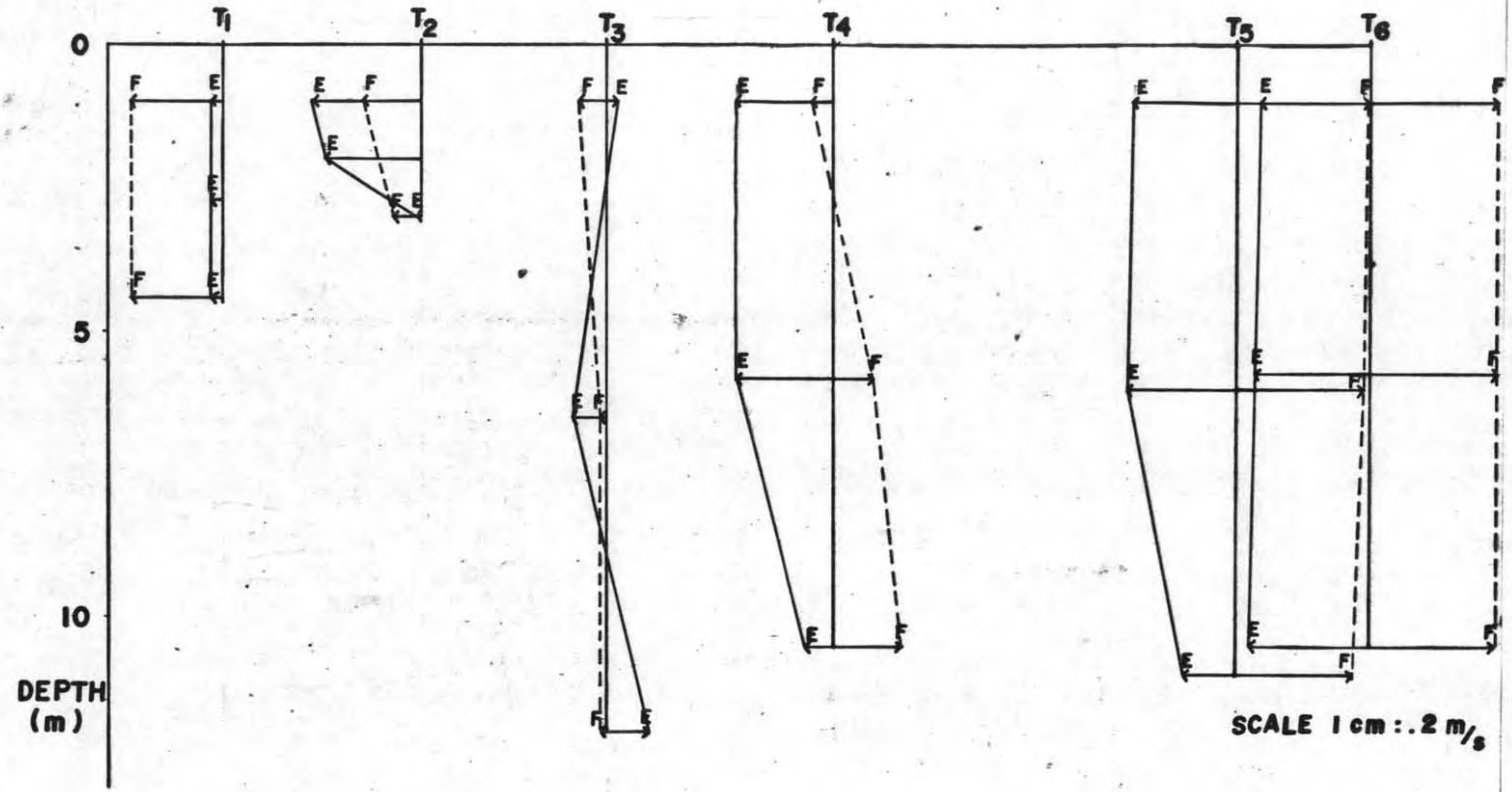
FIGURE 4.2.2 a ILLUSTRATING THE NORMALIZED CURRENT SPEED DISTRIBUTION WITH DEPTH ALONG THE MID-CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING LOW-FLOW.



AUGUST 1979

FIGURE 4.2.2 b. ILLUSTRATING THE NORMALIZED CURRENT SPEED DISTRIBUTION WITH DEPTH ALONG THE MID CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING HIGH FLOW.

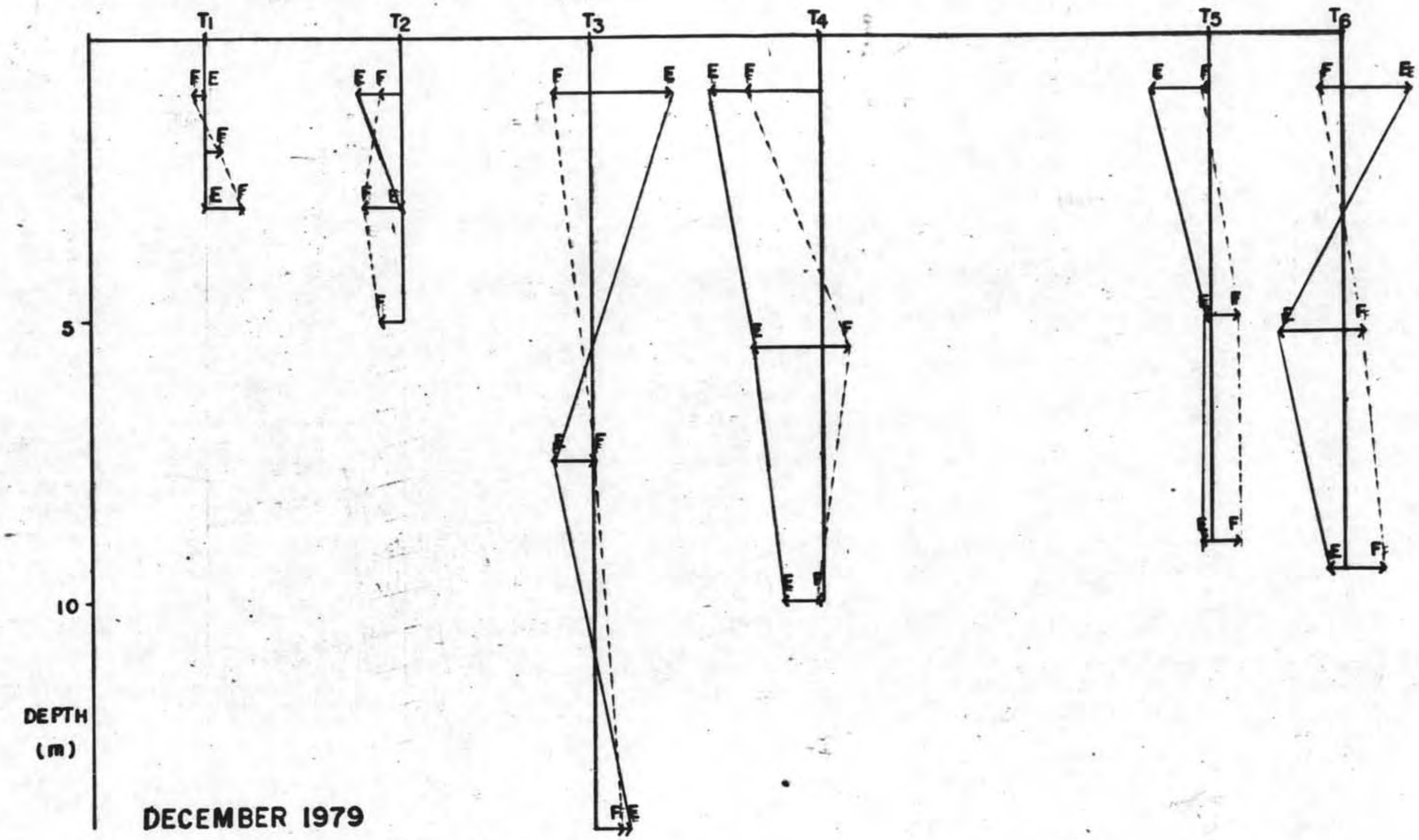


FIGURE 4.2.2 c ILLUSTRATING THE NORMALIZED CURRENT SPEED DISTRIBUTION WITH DEPTH ALONG THE MID-CHANNEL COURSE OF THA CHIN ESTUARY COVERING THE DISTANCE OF 10.6 kms. UPSTREAM FROM THE RIVER MOUTH DURING INTERMEDIATE-FLOW.

calculated mean throughout the 2 field survey programmes are summarized and presented in Figures 4.2.3 a, 4.2.3 b. Unfortunately, the data during the low-flow condition in March is missing due to the instrument breakdown. Generally, the dissolved oxygen pattern of waters in the Tha Chin river exhibits a seaward increasing picture during both ebb and flood stage. However, the fluctuation in dissolved oxygen at the position slightly landward from the river mouth is noticed.

Variations in the dissolved oxygen pattern, as can be concluded from this study, is a function of sampling time of the day (Figure 4.2.4) geometry of the channel cross-section, and pollution condition of the river water. At T4, in particular, pollutions from various point-sources have been discharged into Tha Chin river and as a result lowering the dissolved oxygen contents. In addition, between T2 and T3 the abnormally deep depression in the channel bottom may have the negative effect on the dissolved oxygen content. Nevertheless, the geometry of channel cross-sections have gradually changed in the seaward direction, namely, wider shallower, and as a consequent enabling the increase in dissolved oxygen content.

4.2.4 pH

Observation of the pH of estuarine water along 10.6 kms. distance landward from the river mouth reveals only a slight change in value from 7.2 to 8.1. However, during the high-flow condition the pH pattern is slightly lower, approaching the value of 7, whereas during the low-flow condition the pH range is between 7.5 and 8.1. Obviously the lowering

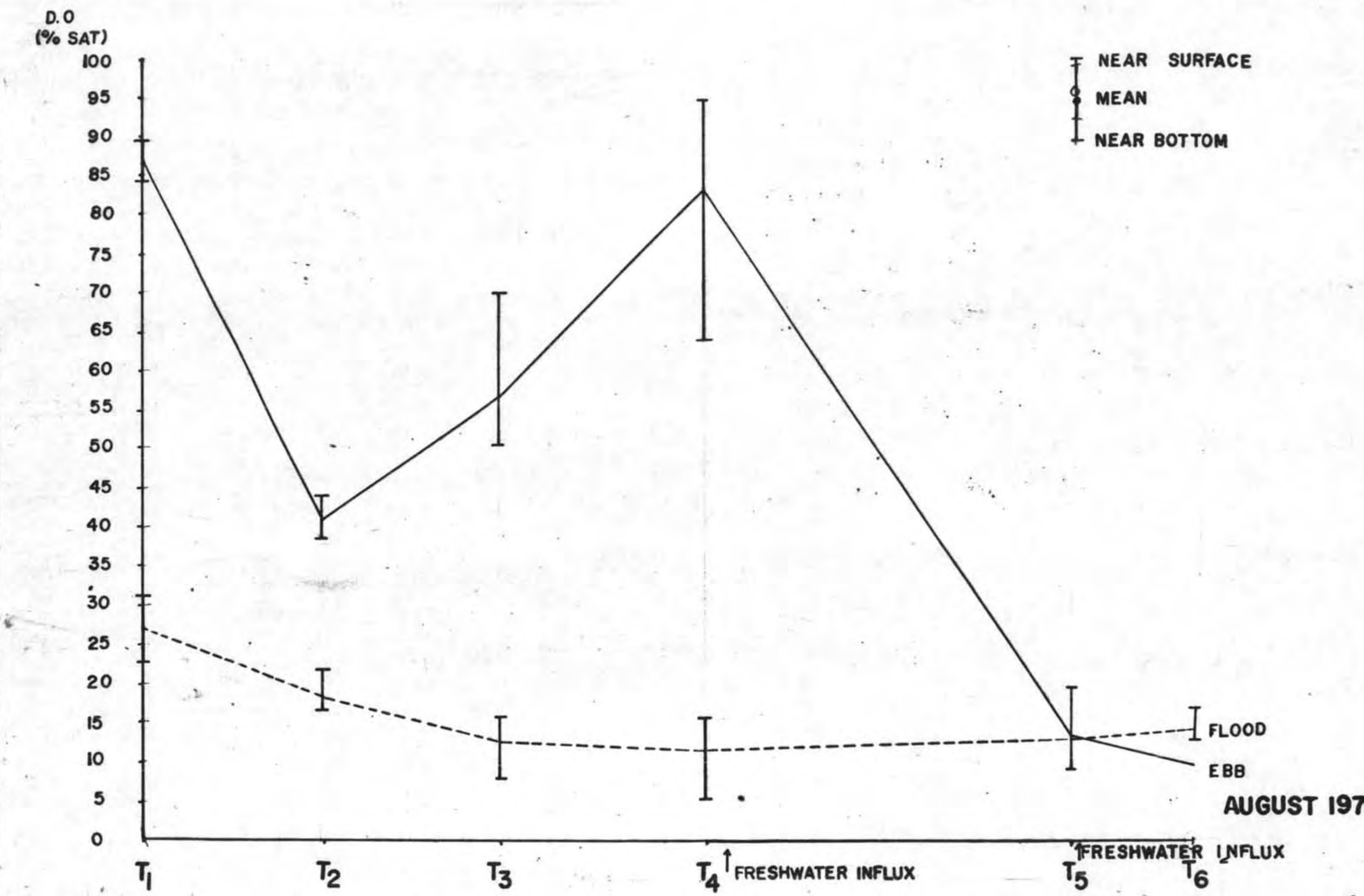


FIGURE 4.2.3a VARIATION OF DISSOLVED OXYGEN DURING THE HIGH-FLOW CONDITION IN AUGUST AT EBB AND FLOOD STAGES, AS OBSERVED IN THE MID-CHANNEL NEAR SURFACE, NEAR BOTTOM INCLUDING MEAN ALONG THA CHIN ESTUARY.

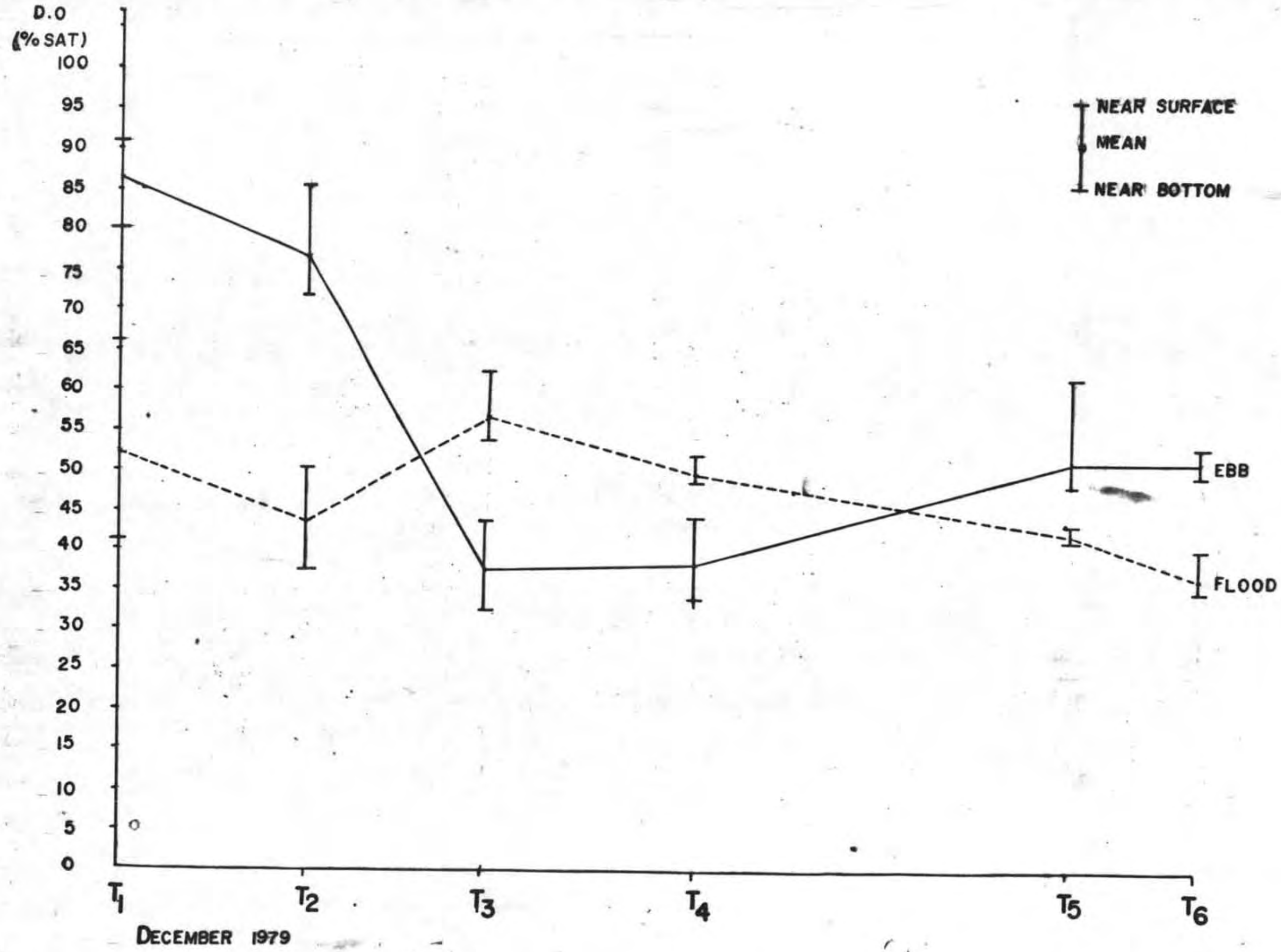


FIGURE 4.2.3 b VARIATION OF DISSOLVED OXYGEN DURING THE INTERMEDIATE-FLOW CONDITION IN DECEMBER AT EBB AND FLOOD STAGE, AS OBSERVED IN THE MID-CHANNEL NEAR SURFACE, NEAR BOTTOM INCLUDING MEAN ALONG THA CHIN ESTUARY

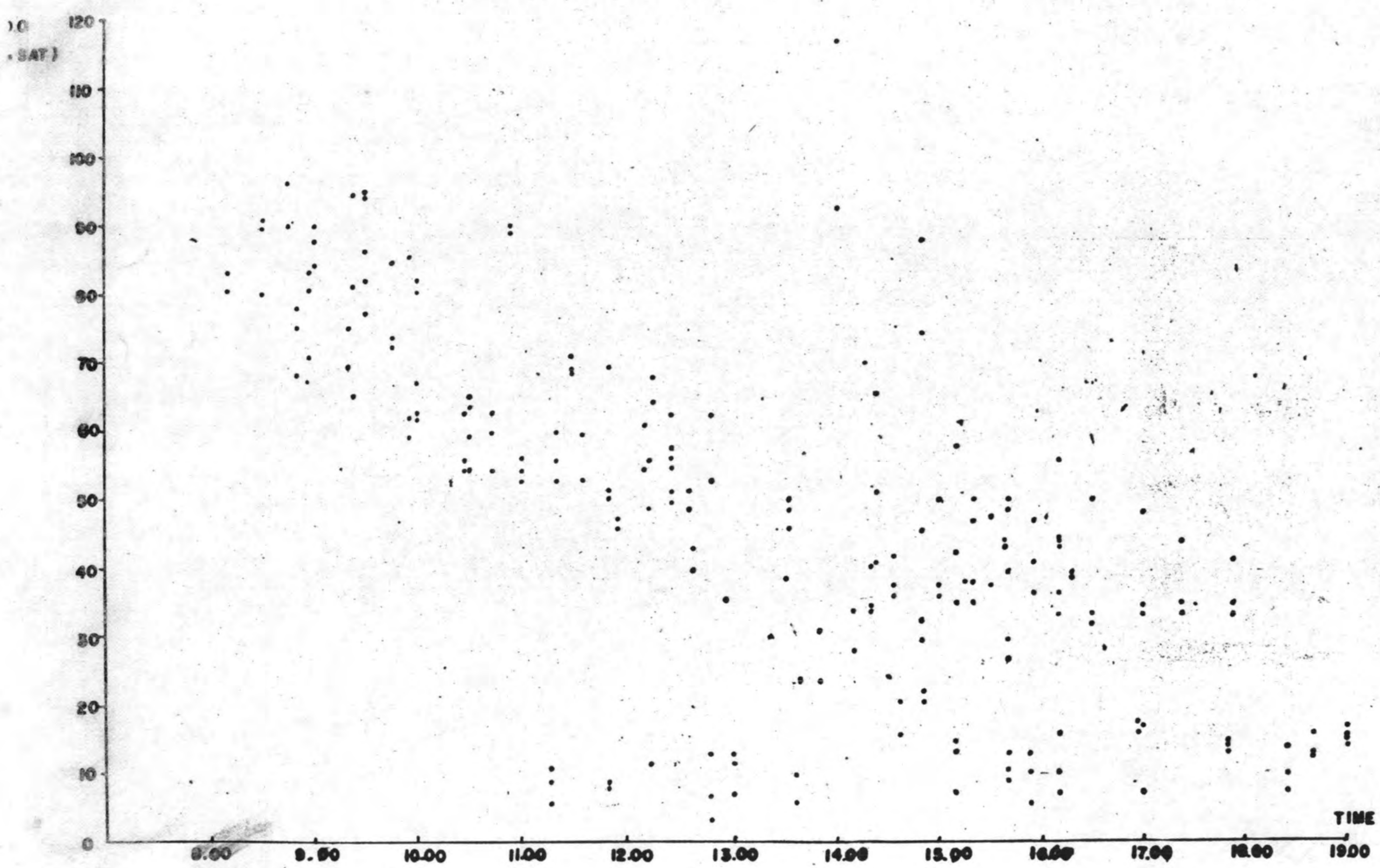


FIGURE 4.2.4 RELATIONSHIPS BETWEEN DISSOLVED OXYGEN CONTENT AND TIME OF DAY, DATA OBTAINED FROM 3 DIFFERENT SURVEYS.

of pH value is influenced by the influx of freshwater from upstream which mainly occurs during the high-flow condition. On the contrary, the increasing in pH is due to the intrusion of salt water into the channel course which mainly occurs during the low-flow condition. Besides, the flood and ebb have an additional effect to the pH of the estuarine water.

4.2.5 Interrelationships of Estuarine Oceanographic Parameters.

All data obtained from 3 field surveys regarding the salinity of Tha Chin estuarine waters were plotted against the dissolved oxygen values (percent saturation) as shown in Figure 4.2.5. Theoretically, the dissolved oxgen content is a function of salt content, temperature, partial pressure, etc. Increasing salt content in the water with result in the decreasing of dissolved oxygen content. In this study it is apparent that the low salinity water shows the dissolved oxygen content of approximately 6 percent saturation. Within an increasing salinity between the range of 2-15%., the dissolved oxygen content is progressively increased. However, when the salinity increases from 15%. to approximately 30%. the dissolved oxygen content exhibits a decreasing trend in a relatively expanded manner. It is concluded that the landward estuarine water shows relatively low values of both dissolved oxygen and salinity. As moving toward the river mouth the salinity has been significantly increased whereas the dissolved oxygen content shows relatively higher values distributed within the wider range. This could be explained in terms of the influence of salt water from the shallow marine of the offshore zone.

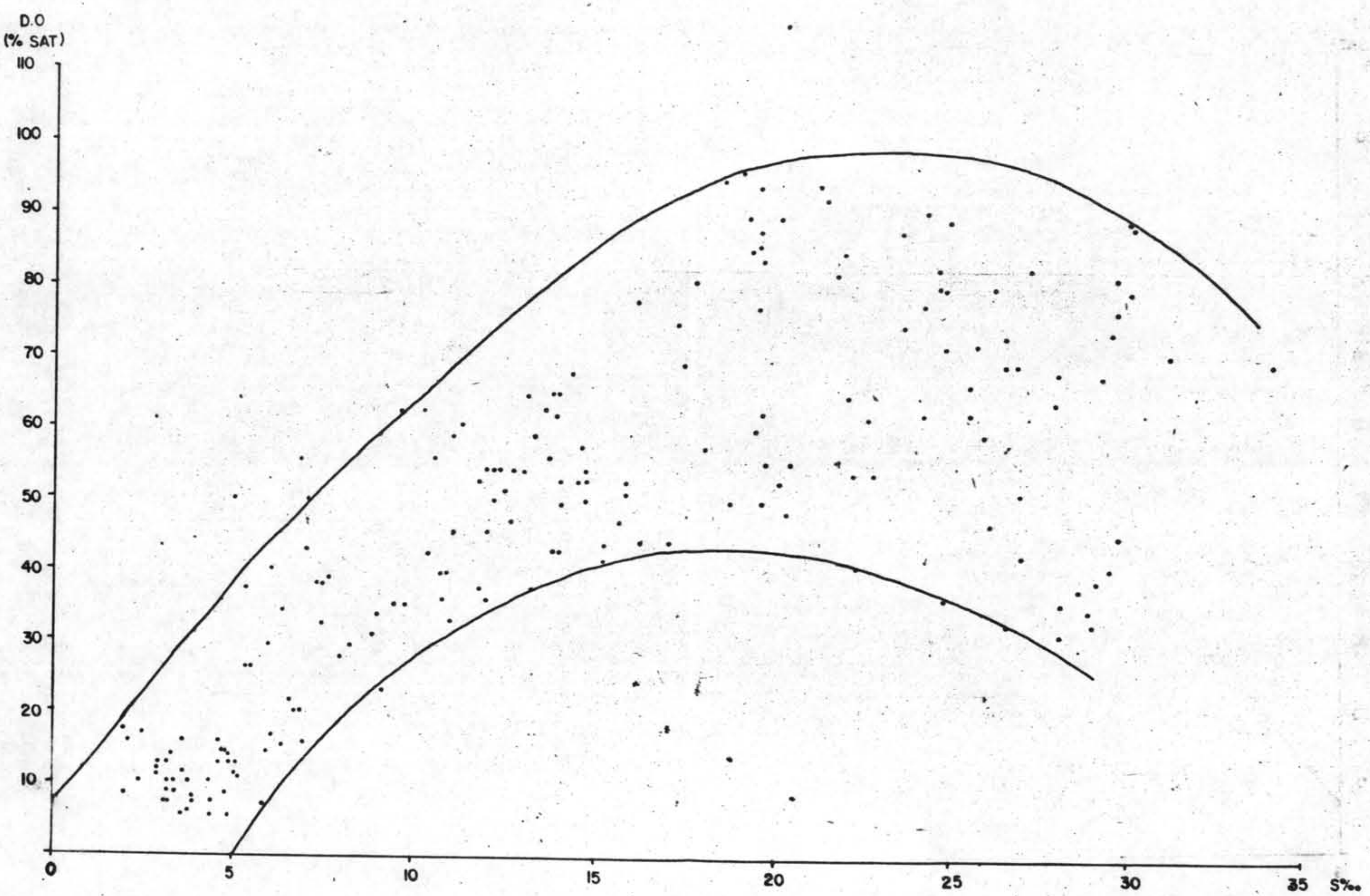


FIGURE 4.2.5 ILLUSTRATING THE RELATIONSHIPS BETWEEN SALINITY AND DISSOLVED OXYGEN OF THE THA CHIN ESTUARINE WATER.

In addition, an attempt has been made to determine the relationships between salinity and pH of the estuarine water from Tha Chin river using the data obtained from 3 field surveys. The result is summarized and presented in Figure 4.2.6. Generally, the upstream water shows low pH (7.1 - 7.3) and low salinity of 0 to 5 %.. As moving toward the river mouth the salinity increases with progressively increase in pH. This relationships may be expressed as positive linear as follows :

$$pH = 0.022 \ S \ ‰ + 7.183.$$

The correlation coefficient is 0.800 which indicates high correlation between these two parameters. However, it is interesting to note that the relatively narrow distribution pattern in the upstream area as compared with the wider distribution pattern toward the river mouth.

In order to confirm the relationships between salinity and dissolved oxygen of the Tha Chin estuarine water previously discussed, the diagram illustrating relationships between pH and dissolved oxygen has been prepared in Figure 4.2.7. It is interesting to note the positive linear relationships of

$$pH = 0.006 \ D.O. + 7.28$$

with correlation coefficient of 0.577. With the increasing pH in a relatively narrow range, the dissolved oxygen content exhibits wider degree of distribution. This slows that pH has little influenced on the dissolved oxygen content as compared with the salinity.

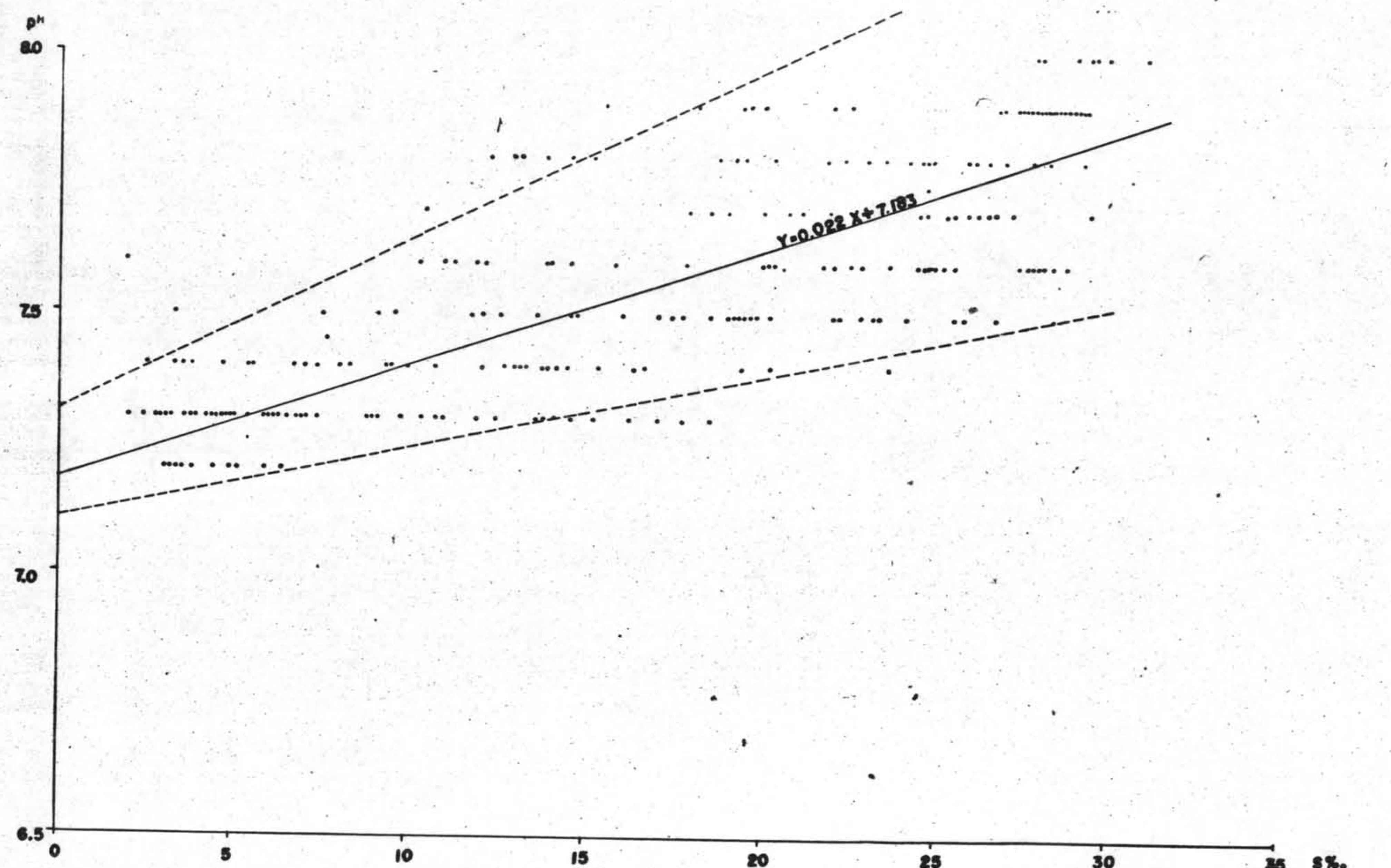


FIGURE 4.2.6 ILLUSTRATING THE RELATIONSHIPS BETWEEN SALINITY AND pH OF THE THA CHIN ESTUARINE WATER

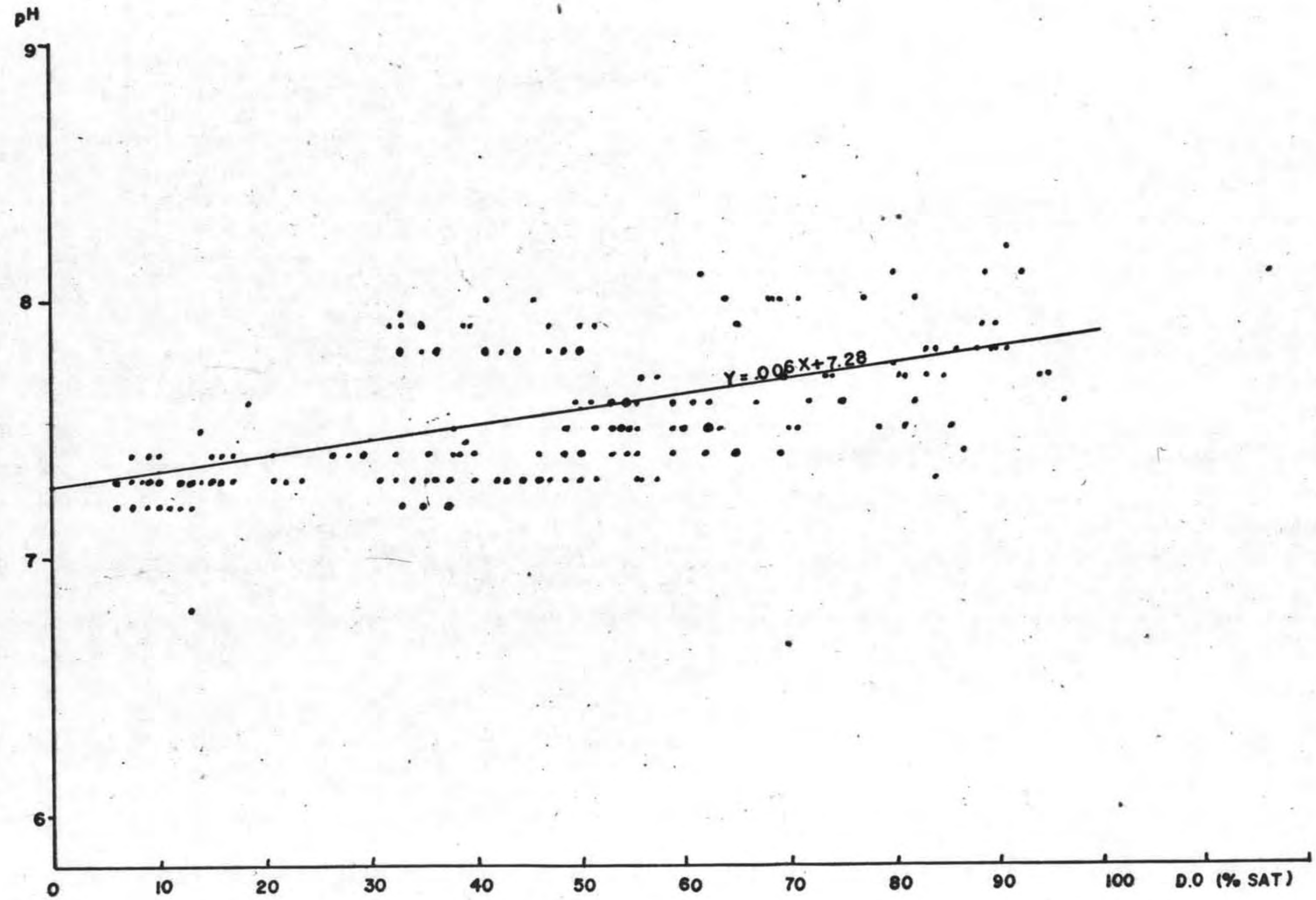


FIGURE 4.2.7 THE RELATIONSHIPS BETWEEN DISSOLVED OXYGEN CONTENT AND pH OF THE THA CHIN ESTUARINE WATER.

4.3 Estuarine Topogrophy and Sediments

The background information concerning the bottom topography of the Tha Chin estuary employed in this study is based on the bathymetric chart of Hydrographic Department, Royal Thai Navy (Figure 4.3.1). Additional echo sounding surveys carried out across six channel traverses are supplemented (Figure 4.3.2).

The course of the Tha Chin river under the area of present investigation may be divided into 3 sections. First, the most seaward section from km.0. (Traverse no.1) to about km. 3.8 upstream (above Traverse no.3), the channel is relatively straight with as axis oriented in between N 324°E to N 339°E direction. At km. 3.8 the axis changes abruptly to N 032°E, followed by meandering channel which has radius of curvature of .475 and .743 km. respectively. The meandering channel has meander wavelength, as defined by Brice, of 3.683 kms. and 2.65 kms. wave amplitude which ends at km. 10.6. From here the last straight reach runs under N 341°E, proceeding up the river.

The longitudinal profile of the channel is projected at a depth of 10.64 m. below M.S.L. from the last survey on December 1979 (as presented in Figure 4.3.2). At traverse no.6 the Tha Chin attains width of 330 meters, while its depth is about 10.5 meters. A meander loop lies between km. 9.4 and km. 3.0. Sinuosity ratio (Brice) is in the order of 2.34. The final stretch from km. 3 to the sea the depth gradually decreases, while the river gradually widens out. The channel for navigation are more satisfactory on the east side of the river.

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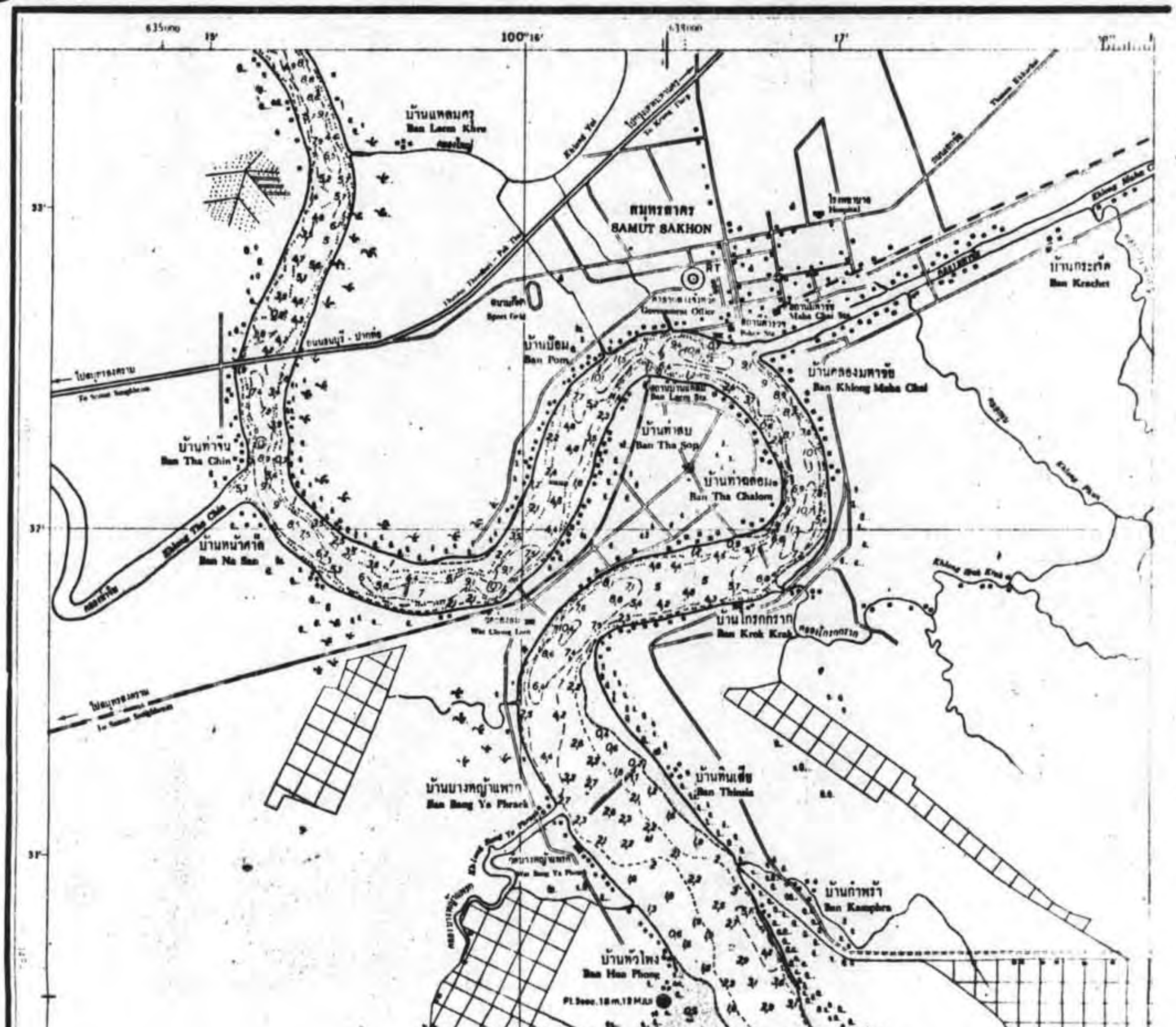

Figure 4.3.1 A bathymetric chart of Tha Chin river, scale 1:37,500

(after Hydrographic Department, R.T.N., 1974)

Figure 4.3.2 The longitudinal profile of the mid-channel course and the cross-sectional profiles along the Tha Chin estuary.

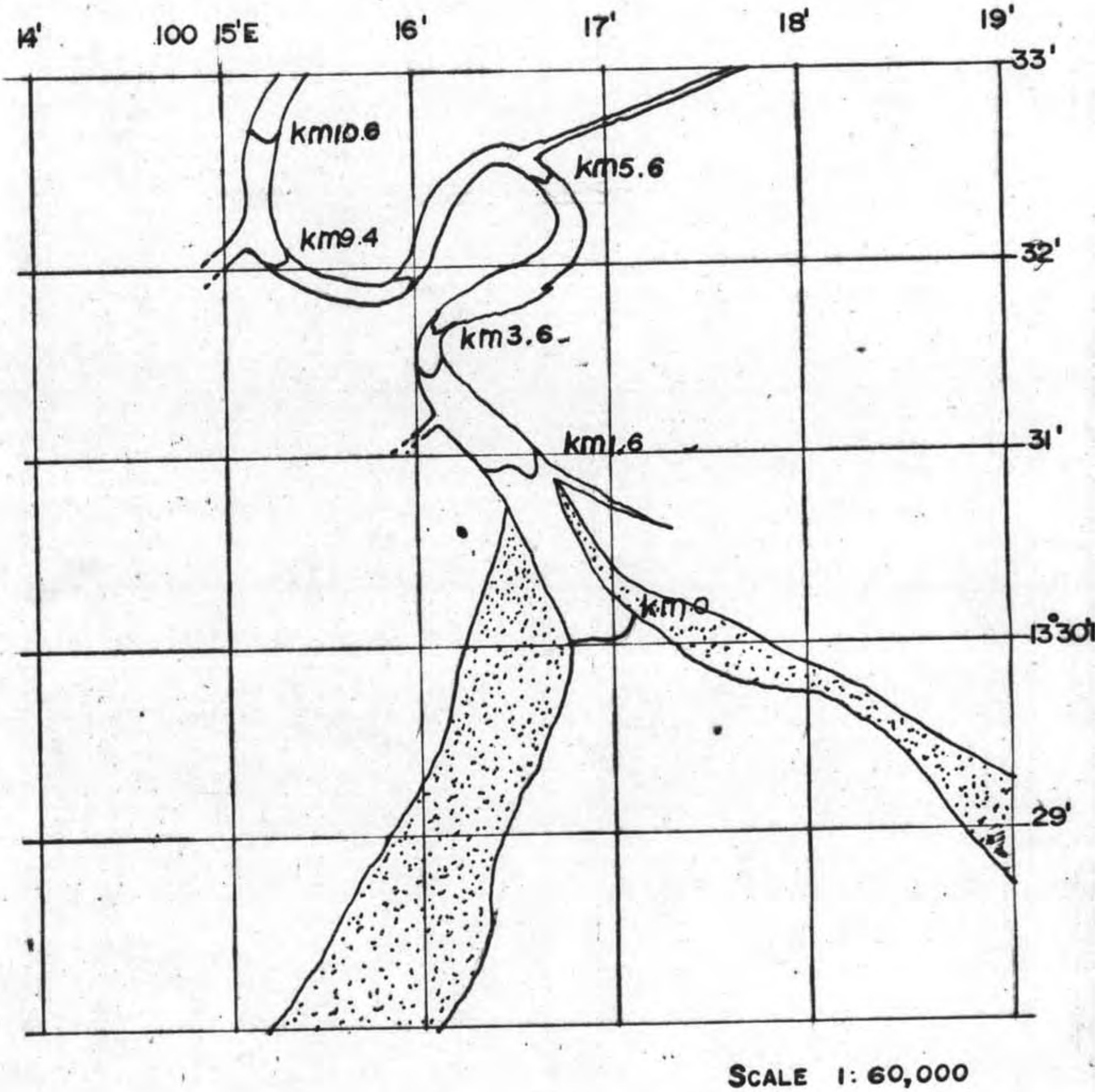

Figure 4.3.3 Cross-sectional profile along the Tha Chin estuary.

The colour of bottom sediments is identified by using Munsell standard rook colour system. Although the colour of the bottom sediments varies widely, nearly all sediments fall within the range of four colours : 1) green-yellow including shades of HUE 56 y, HUE 106 y, 56 y; 2) green including HUE 56, 106; 3) neutral gray including N1, N2, N3; 4) yellow including HUE 10 y, HUE 5 y, 5 y. (as presented in Table 4.3.1).

Differences in colour may due to the following constituents : clay minerals, which make up the bulk of the fine-grained sediment, are often olive coloured; organic contstiuents such as fecal pellets and diatoms may also contribute. Iron oxide, which occurs as a coating on sand grains, yields yellowish brown colours; reduced ferrous-rich compounds yield gray-coloured sediments. Highly reduced organic and inorganic compounds yield black-coloured sediments. In addition, the reducing environment of organic-rich sediment is believed to be responsible for the production of hydrogen-sulfide. Land-derived ferric iron mixed with olive-coloured constituents may be responsible for the olive brown colour in sediments.

The black, brown, green or gray sediment colour are usually found in low energies estuaries. (This type is characterized by low to moderate current speed) (Davis, 1978). Colour banding and mottling occur frequently. Sometimes the colour banding is controlled by the environment of deposition. This is especially true of black estuarine sediments in which the colour is caused by metastable hydrotroilite ($FeS.nH_2O$). Hydrotroilite converts to pyrite with time and the sediment colour changes from black to gray or green. Ruducing conditions in the sediments are

Table 4.3.1 Colour of the bottom sediment from three surveys.

(Munsell standard rock colour system)

Colour	Code no.	frequency	Remarks
Greenish black	5 G 2/1	13	absent at T3
Grayish olive green	5 GY 3/2	12	-
Dusky yellowish green	10 GY 3/2	10	-
Grayish olive	10 Y 4/2	9	absent at T4, T5
Greenish black	5 GY 2/1	9	absent at T6
Dusky green	5 G 3/2	7	absent at T1, T3, T5
Dark greenish gray	5 GY 4/1	5	absent at T3
Dusky yellow green	5 GY 5/2	4	absent at T4, T6
Moderate olive brown	5 Y 4/4	3	absent at T3, T5, T6
Black	N1	3	absent at T1, T2, T3, T6
Grayish olive	N2	2	absent at T1, T2, T4, T6
Dark gray	N3	2	absent at T1, T3, T4, T6
Dusky blue green	5 BG 3/2	1	absent at T1, T2, T4, T5, T6
Olive gray	5 Y 3/2	1	absent at I1, T2, T3, T4, T5
Olive black	5 Y 2/1	1	absent at T1, T2, T3, T5, T6
Grayish green	10 G 4/2	1	absent at T1, T2, T3, T4, T6

necessary to produce hydrotroilite under oxidizing depositional conditions lighter colours of brown or gray are encountered frequently. Sediment colour reflects this chemical variation and may change from light gray or brown under oxidizing conditions, to black under reducing conditions.

Carbonate-carbon content of the bottom sediment lies in the range between 0.08-2.07 percent of dried weight sample and does not have much difference from one survey to another. Mean value is 1.30 $\pm$ 0.38 percent from three surveys. At traverse no.3 carbonate-carbon content reaches maximum of 1.51 $\pm$ 0.20 percent and decreases slightly towards both upstream and downstream (Table 4.3.2). In the same manner, total organic carbon (Ignition loss) does not show any difference between each survey. This value ranges from 4.36-17.54 percent of dried weight sample and has 10.26 $\pm$ 3.07 percent of mean value. Total organic carbon content reaches maximum of 11.89 $\pm$ 2.35 percent at traverse no.2 and decreases slightly upstream. Traverse no.4 which lies at lower reach of Klong Mahachai has remarkably high value of total organic carbon comparing with upstream traverse (Table 4.3.3). This may result from waste dumping at morning market and pier along Klong Mahachai.

The bottom sediments of lower Tha Chin river are mostly silt and clay in sights and produces a smell of hydrogen sulfide-like. At some stations high amount of artifacts and wastes are observed i.e. T3-1, T4-3.

Suspended sediment content of the Tha Chin estuary varies greatly and shows significant difference during 3 surveys (Figure 4.3.4). The maximum range (20 – 500 mg/l) occurs during high-flow condition in August

Table 4.3.2 Mean value of carbonate-carbon content of bottom sediment from three surveys.

	percent of dried weight sample
Total mean	1.30 ± 0.38
T1	1.48 ± 0.37
T2	1.37 ± 0.36
T3	1.51 ± 0.20
T4	1.36 ± 0.30
T5	0.96 ± 0.29
T6	1.12 ± 0.25

Table 4.3.3 Mean Value of total organic carbon (Ignition loss) of bottom sediment from three survey.

	percent of dried weight sample
Total mean	10.26 ± 3.07
T1	11.87 ± 3.61
T2	11.89 ± 2.35
T3	8.55 ± 3.28
T4	10.34 ± 2.05
T5	9.26 ± 2.36
T6	8.82 ± 2.89

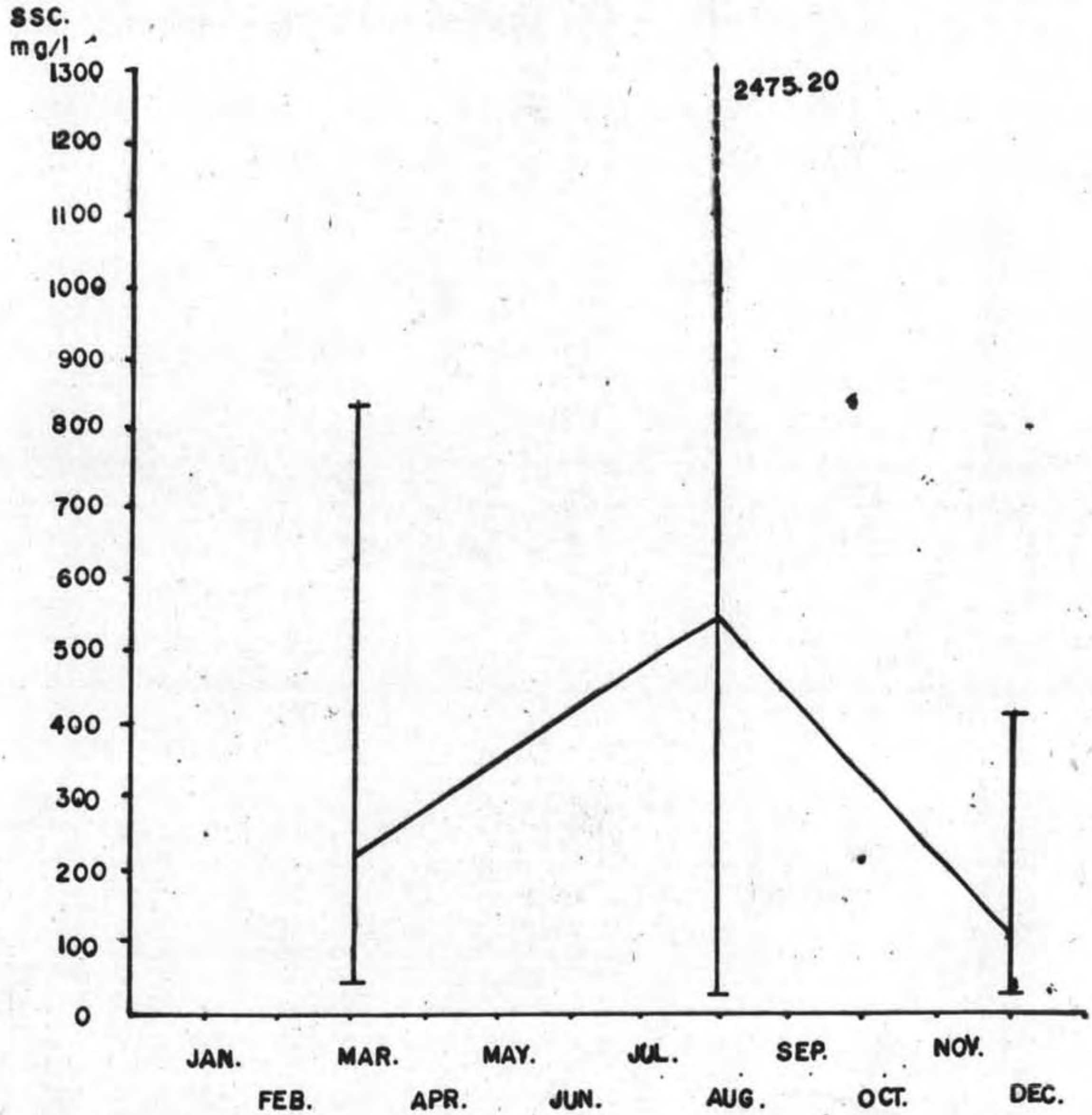

Figure 4.3.4 Illustrating the range and mean of suspended sediment content in 3 flow conditions: high-flow in August, intermediate-flow in December and low-flow in March.

with maximum mean (350 mg/l). At low-flow condition in March the suspended sediment content shows a relatively higher mean (220 mg/l) and greater range (30-850 mg/l), as compared with the intermediate-flow condition in December (range 20-450 mg/l, mean 120 mg/l).

The data concerning the suspended sediment content obtained from the 3 field investigation surveys for both ebb and flood stages along the Tha Chin estuary are presented and summarized in Figures 4.3.5 a, 4.3.5 b, 4.3.5 c. During the low-flow condition at the ebb stage, the suspended sediment content generally increases in the seaward direction with an extraordinary fluctuation at T2 similar to the seaward increasing pattern of the flood stage. The fluctuation of suspended sediment content at T2 may be dued to the turbulence caused by the increase in speed of fishing vessels passing through the exceptionary deeper channel of that area.

During the high-flow condition, the suspended sediment content shows a seaward increasing pattern of a relatively higher content as compared to the low-flow. However, the fluctuation pattern persists at T2 and T3 similar to that of the low-flow condition. The distribution pattern of suspended sediment during both ebb and flood stages are more or less similar in nature.

It is interesting to note that the suspended sediment distribution pattern along Tha Chin estuary during the intermediate-flow for both ebb and flood stages shows rather uniform characteristic with exceptionary lower suspended sediment content. This could be explained in terms of the balanced influence of the freshwater discharge and the tidal effect.

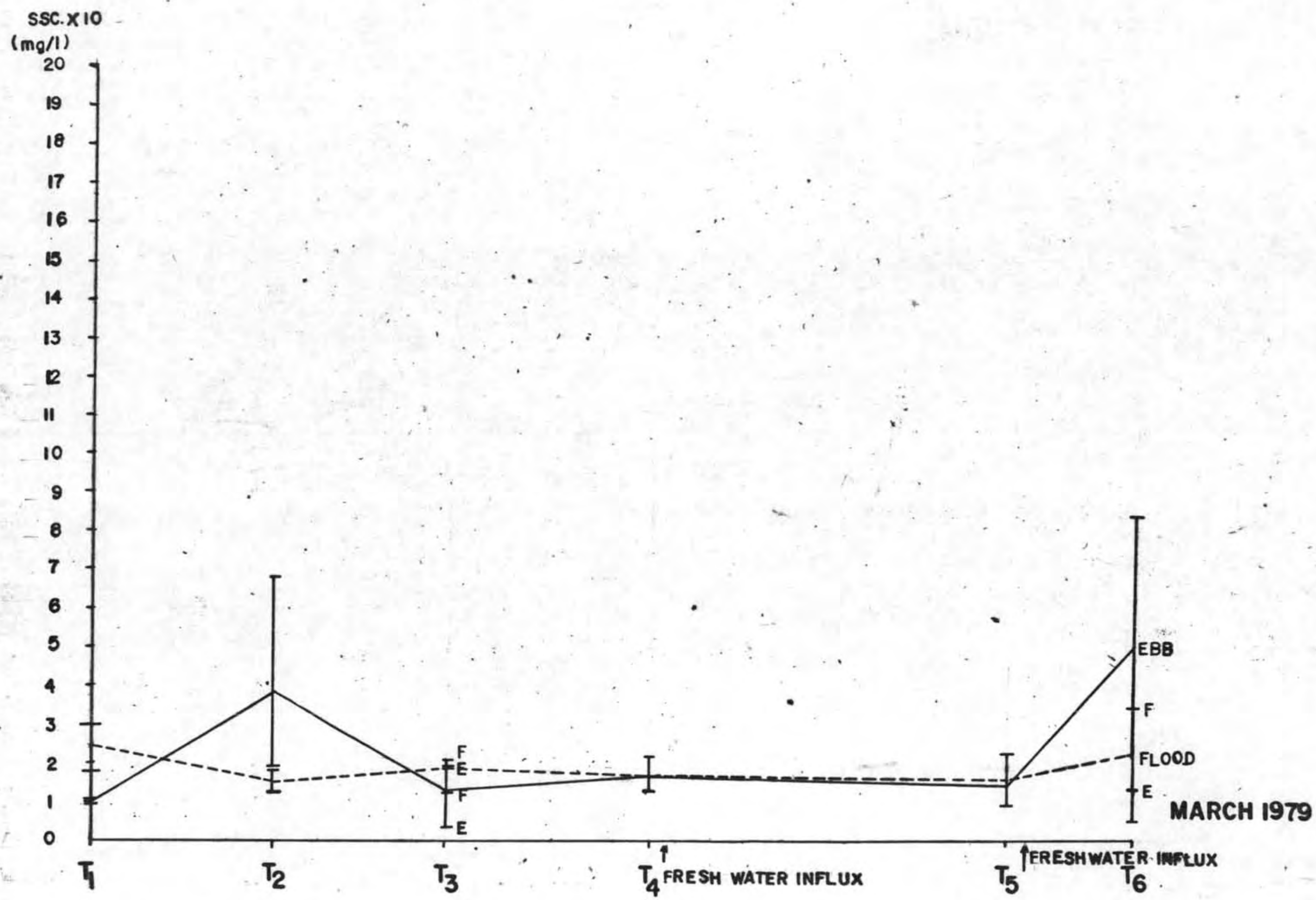

FIGURE 4.3.5 a VARIATION OF SUSPENDED SEDIMENT CONTENT DURING THE LOW FLOW CONDITION IN MARCH AT EBB AND FLOOD STAGES, AS OBSERVED IN THE MID-CHANNEL COURSE ALONG THA CHIN ESTUARY

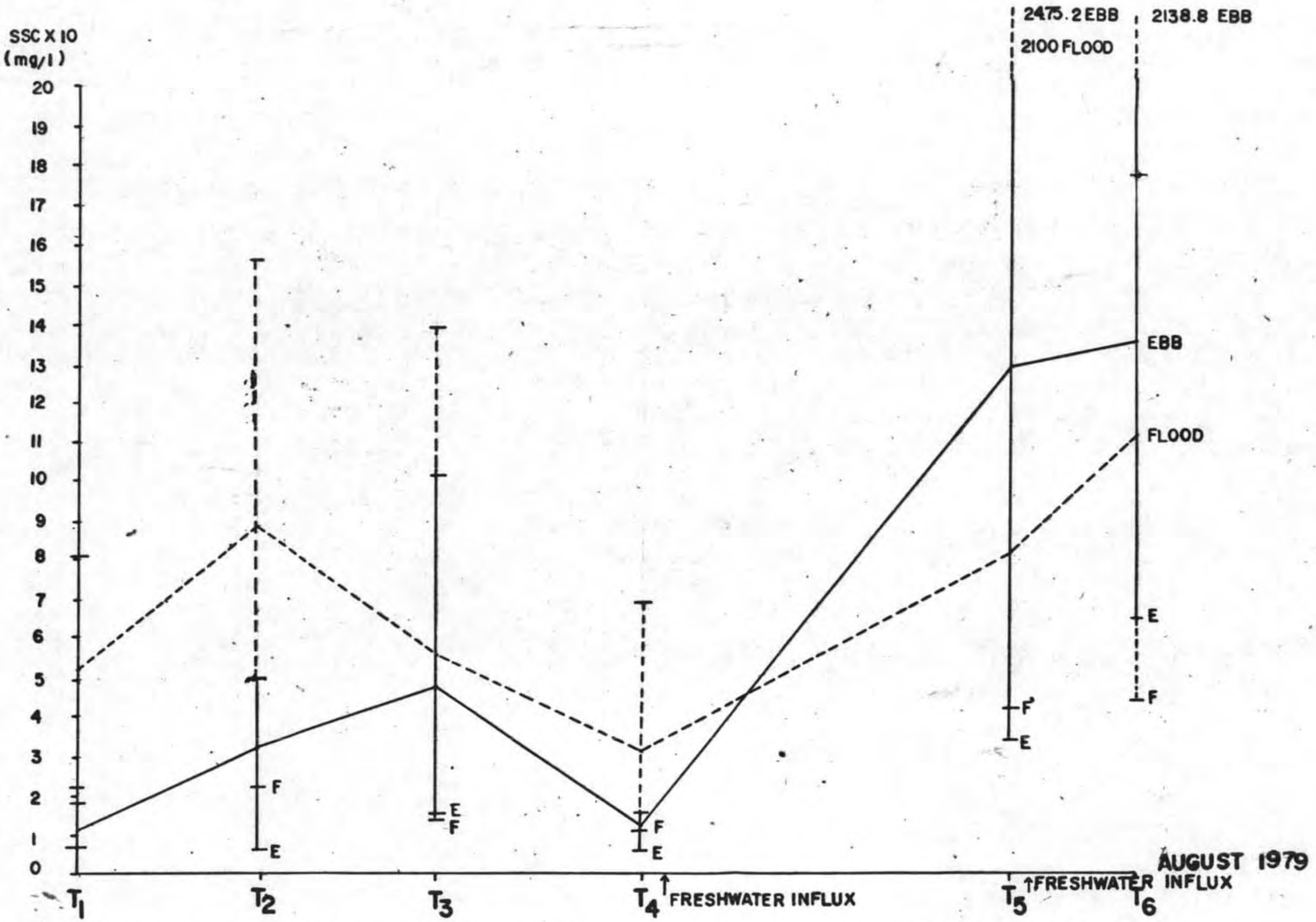

FIGURE 4.3.5.b VARIATION OF SUSPENDED SEDIMENT CONTENT DURING THE HIGH FLOW CONDITION IN AUGUST AT EBB AND FLOOD STAGES, AS OBSERVED IN THE MID-CHANNEL COURSE ALONG THA CHIN ESTUARY

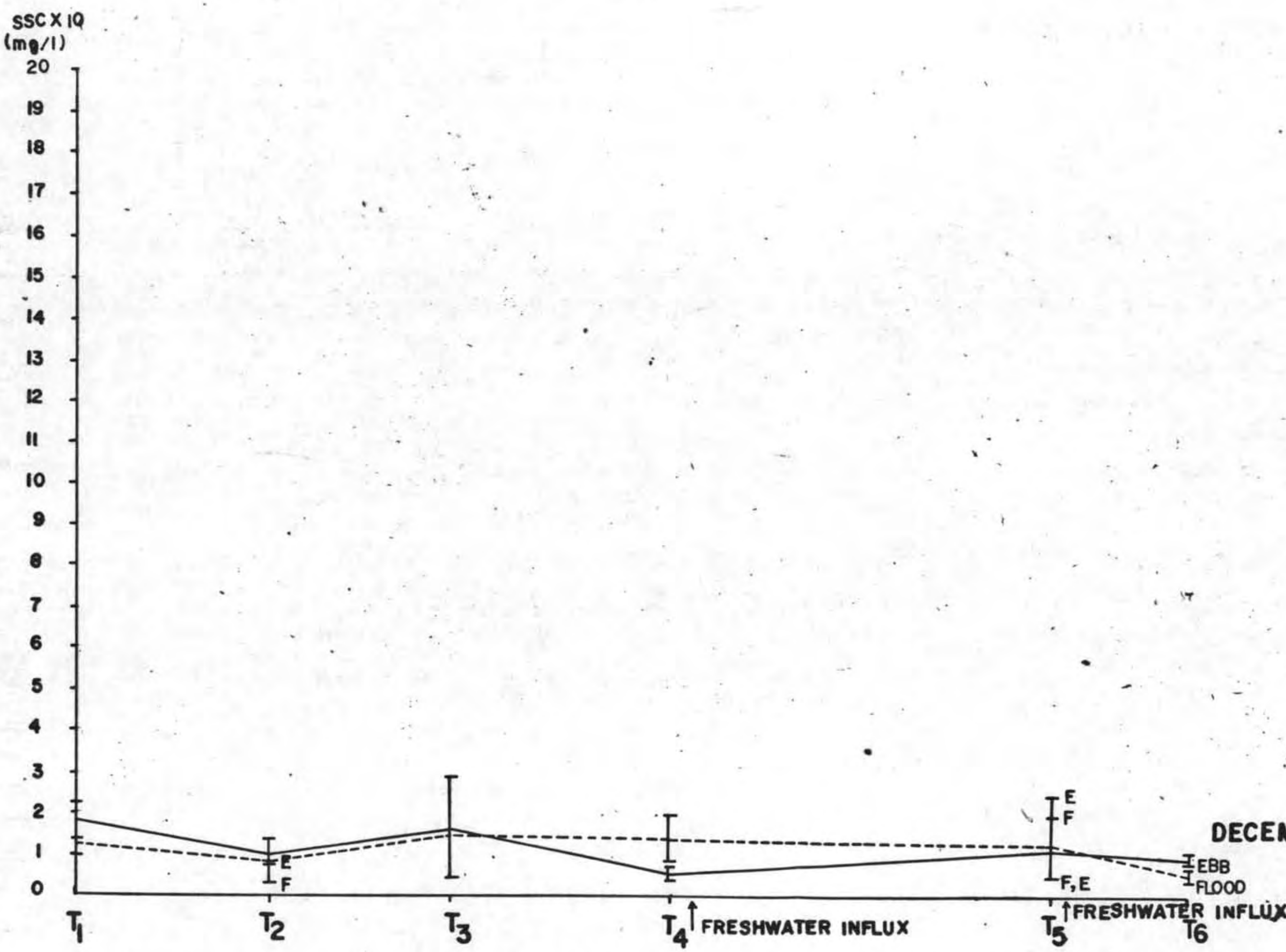

FIGURE 4.3.5 c VARIATION OF SUSPENDED SEDIMENT CONTENT DURING THE INTERMEDIATED FLOW CONDITION IN DECEMBER AT EBB AND FLOOD STAGES, AS OBSERVED IN THE MID-CHANNEL COURSE ALONG THA CHIN ESTUARY

Figure 4.3.6 shows the relationships between suspended sediment content and salinity during 3 flow conditions. The low-flow condition in March shows the suspended sediment content gradually increases as salinity increases. In addition, where the salinity reaches the range 30-35%. the suspended sediment content increases drastically. During the high-flow condition in August, the high suspended sediment content appears in the area of low salinity values and the suspended sediment content progressively decreases as salinity increases. However, it is remarkable to note the relatively uniform pattern of the suspended sediment content which is slightly increased as salinity increases during the intermediate-flow condition in December.

From this study can be concluded that the suspended sediment content is a function of the freshwater discharge and the tidal effect depending on seasonal time of the year. Marine influence is more pronounced during the low-flow condition of Tha Chin river, whereas the freshwater discharge plays an important role during the high-flow condition as far as the suspended sediment is concerned.

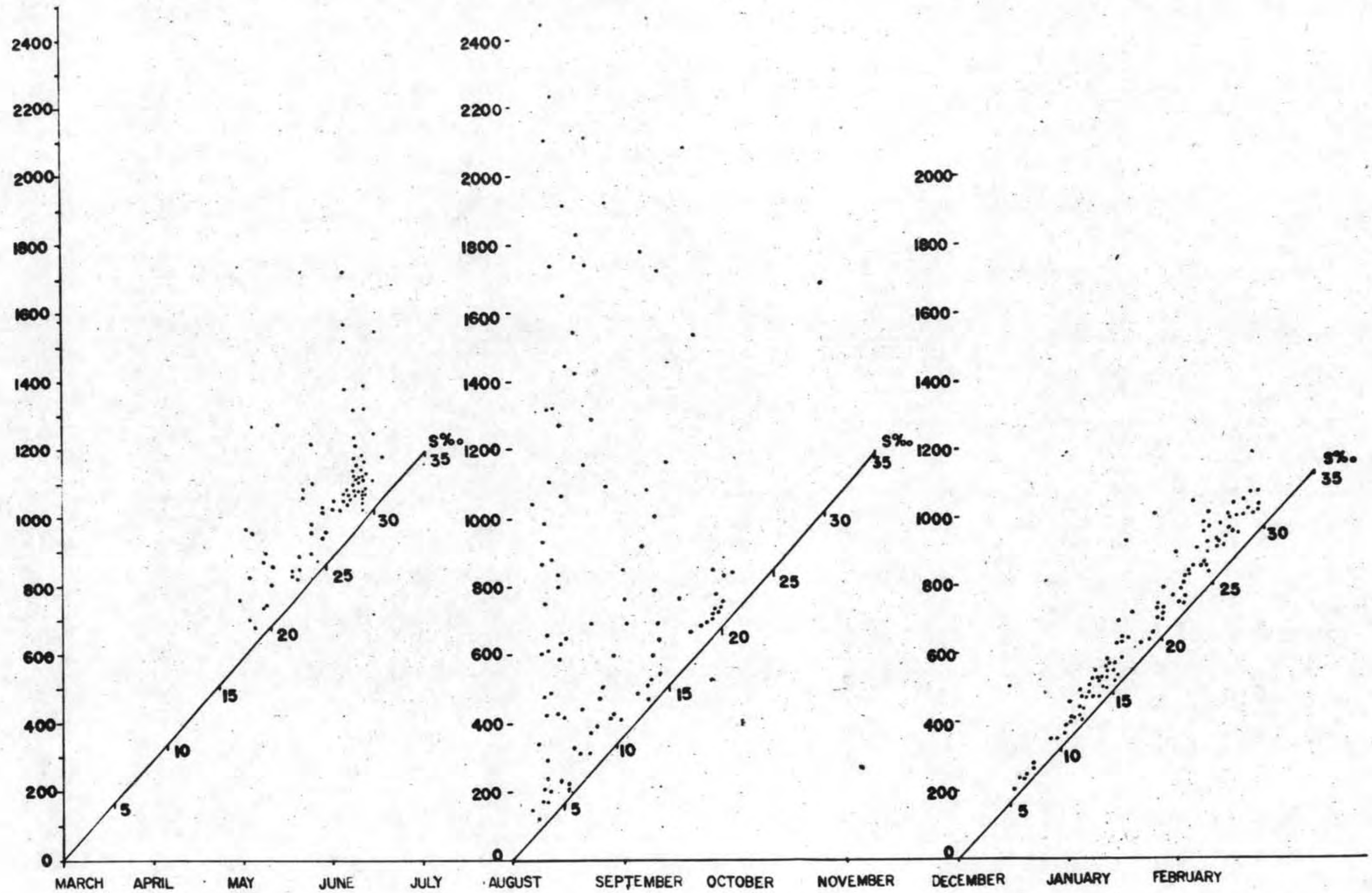

FIGURE 4.3.6 RELATIONSHIPS BETWEEN SUSPENDED SEDIMENT CONTENT AND SALINITY OF THE THA CHIN ESTUARINE WATER IN 3 FLOW CONDITIONS: HIGH-FLOW IN AUGUST, INTERMEDIATE-FLOW IN DECEMBER AND LOW-FLOW IN MARCH